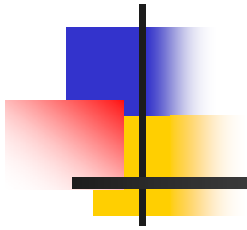


Study of ADC signals from single crystal data

Cosenza INFN Group

(L. La Rotonda, E. Meoni, A. Policicchio, G. Susinno)

Summary

To disentangle Cerenkov and scintillation light, QADC & FADC signals in a single $PbWO_4$ crystal have been collected at different angles between the crystal and the beam.
Measumements performed both with electrons and muons.

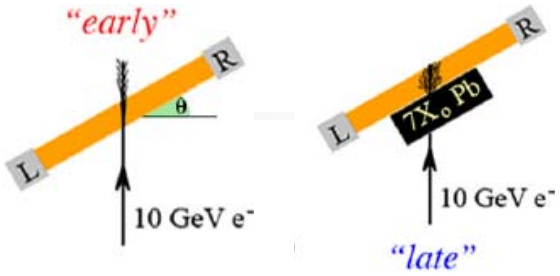
We have studied ADC signals (signal shape and asymmetry) using:

- Electrons showers both in the early stage and in the late stage
- Muons

Data

Electron data:

- **10 GeV electron showers in the early stage:**
  (Run from 784 to 803, Pedestal Run: 804)
- **10 GeV electron showers in the late stage:**
  (Run from 831 to 840, Pedestal Run: 804)



Muon data:

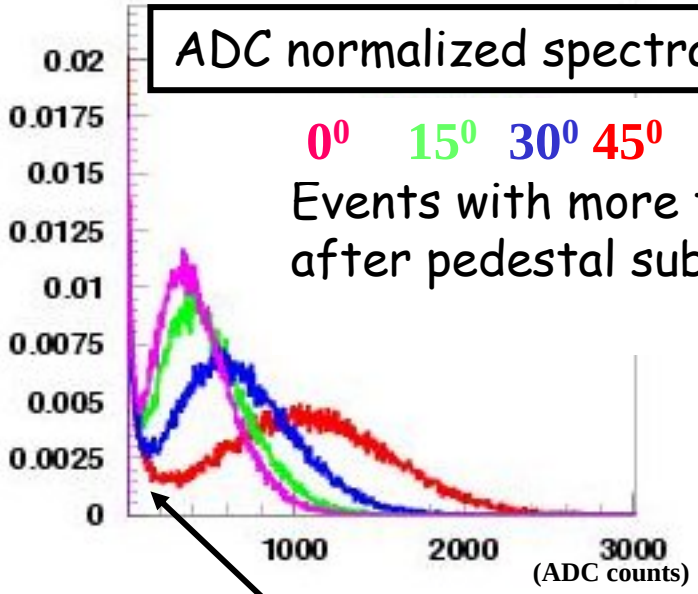
- **150 GeV muons**
  (Run from 846 to 856, Pedestal Run : 524)
- **Parasitic muons** (crystal put 30 cm below line beam)
  (Run from 543-560, Pedestal Run: 524)

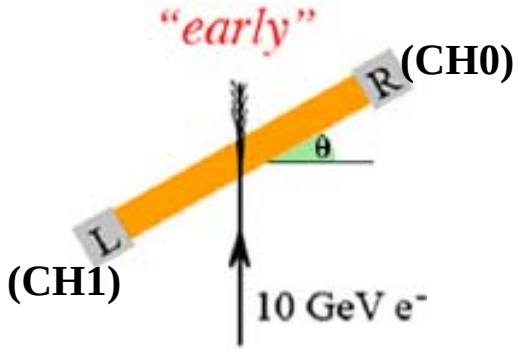
Also some **crystal array data** (to check single crystal data shape):

50 GeV electrons (array at 90^0 respect to the beam,
with cones pointing upstream and with yellow filter downstream)
(Run 1095)

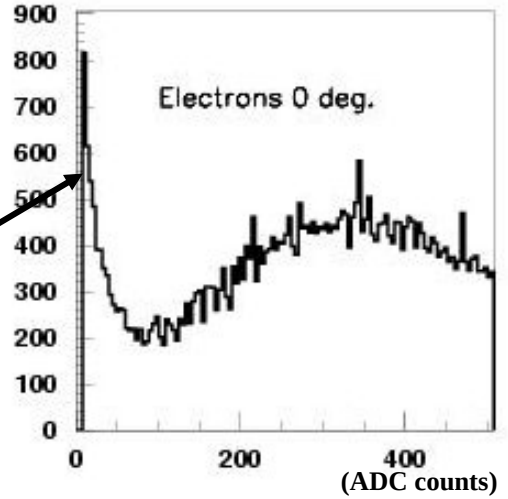
50 GeV electrons (array at 0^0 respect to the beam,
with cones pointing sideward)
(Run 1079)

10 GeV electron showers in the early stage



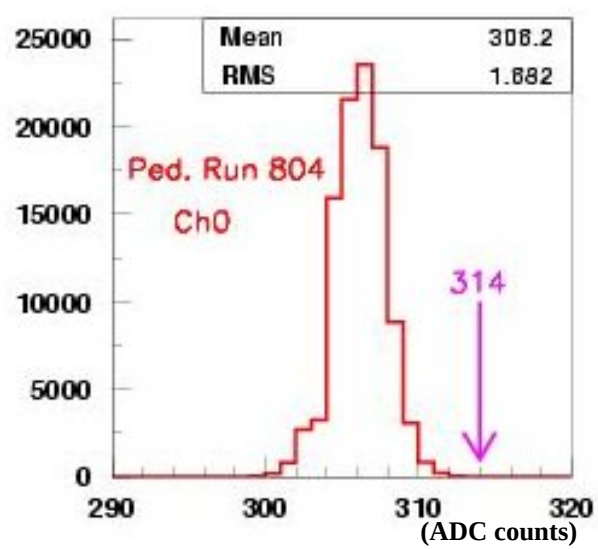


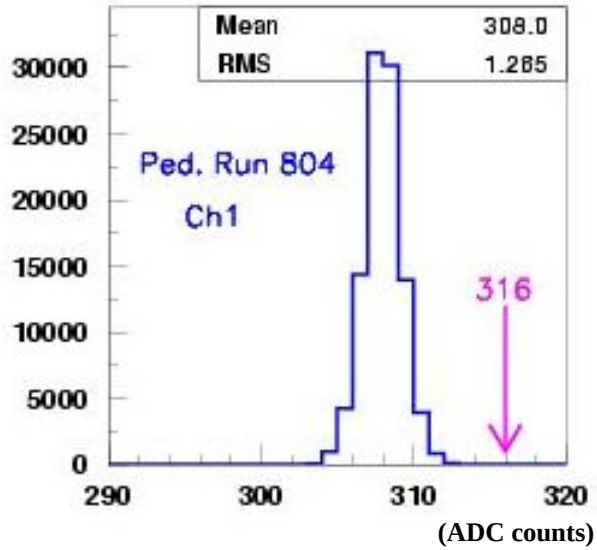
We have checked the origin of the first tail



Checks on the tail

A) Check on the pedestal run

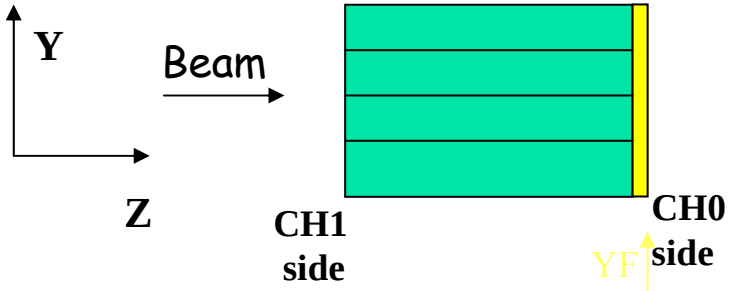


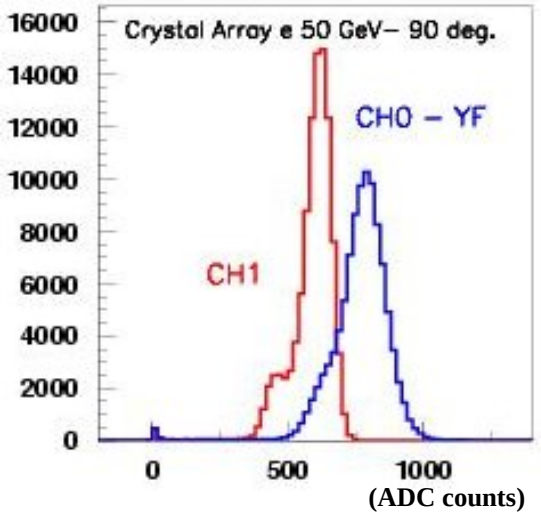


The tails of ADC distributions in the pedestal run don't justify the tail in electron runs

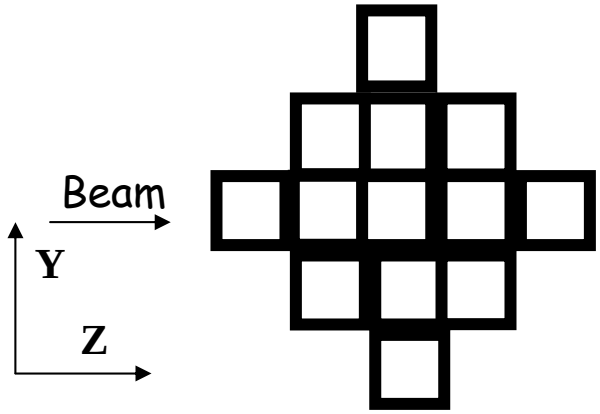
B) Check with electron data taken with crystal array

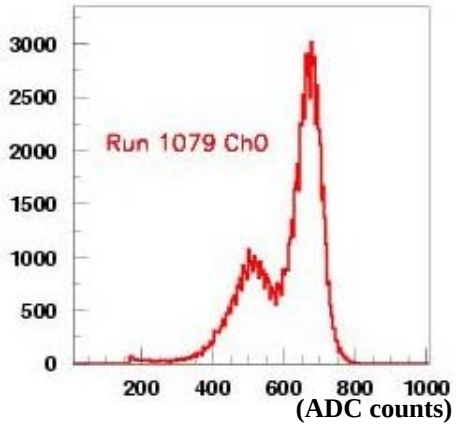
B1) Array at 90^0 respect to the beam, with Yellow Filter downstream with cones pointing upstream

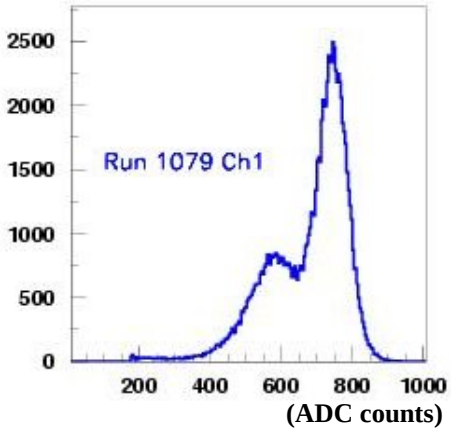




B2)Array at 0^0 respect to the beam, with cones pointing sideward





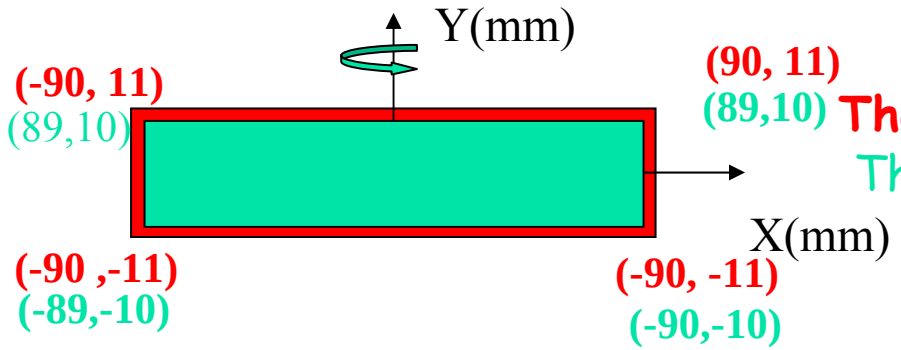


Moving the array in the vertical plane signal structures observed

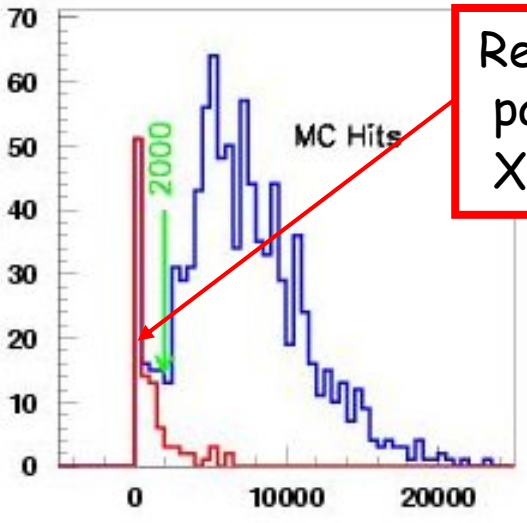
the beam spot is larger the transverse size of the crystal

C) Check with Geant4 simulation of the test beam

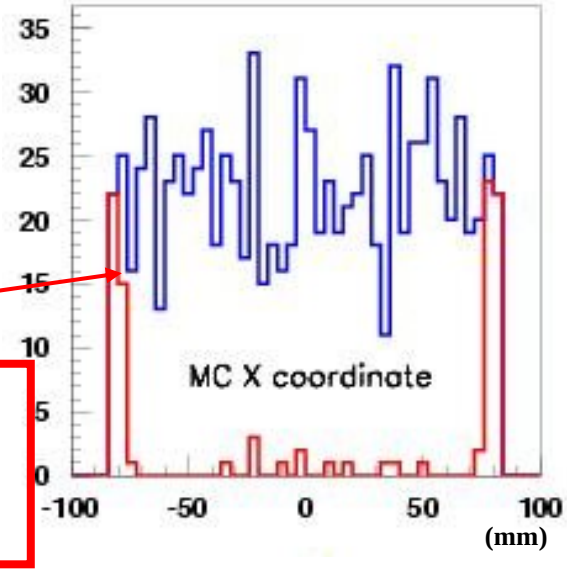
The effect of beam crossing near to the crystal edges have been investigated simulating a very large electron beam with uniform distribution (NO REALISTIC CASE)



Crystal rotated at different angles around vertical axis (shown results at 30^0)



Red line obtained selecting particle crossing:
X > 75mm or X< -75 mm



Red line obtained selecting events with less than 2000 counts

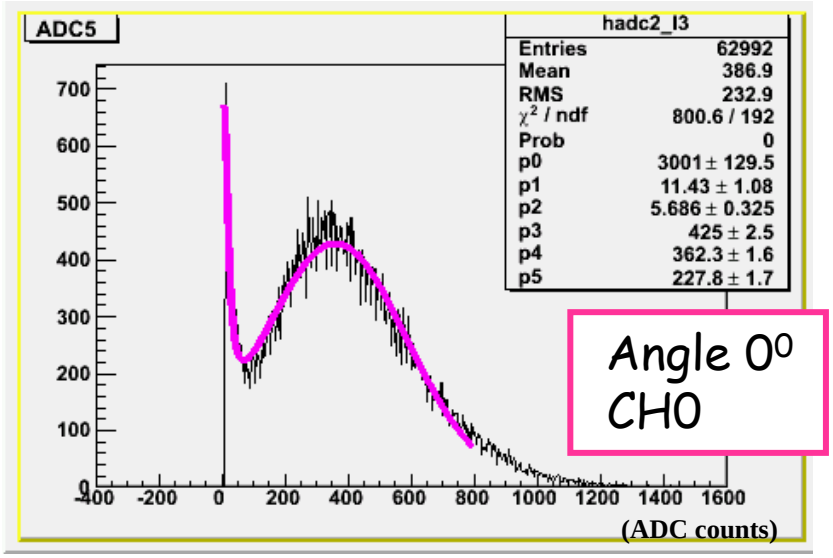
Correlation between low counts and beam crossing near to the X edges is clearly shown

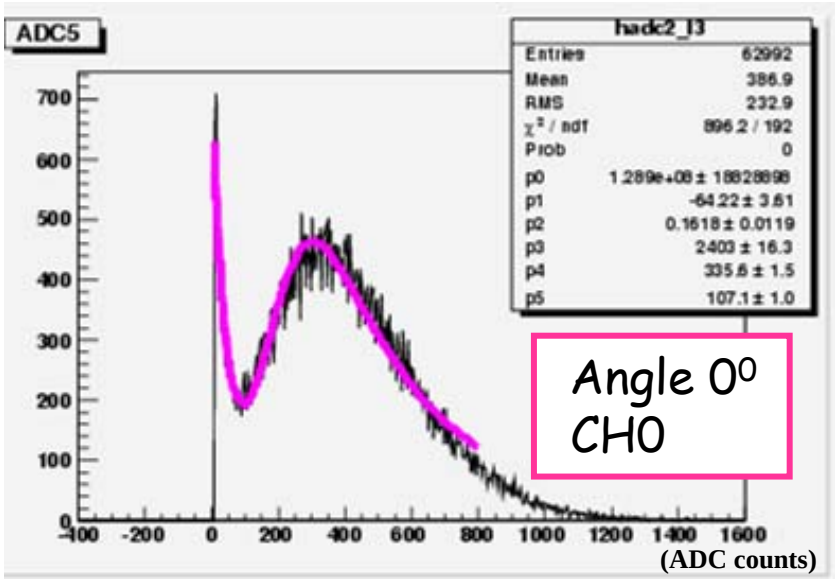
Signal Shape Fit

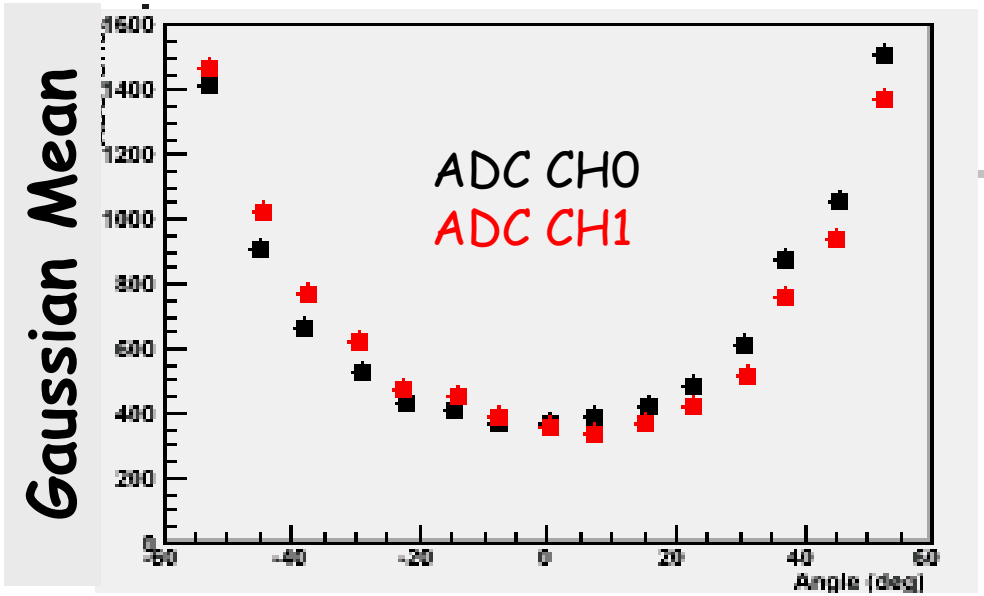
Tried two different fit

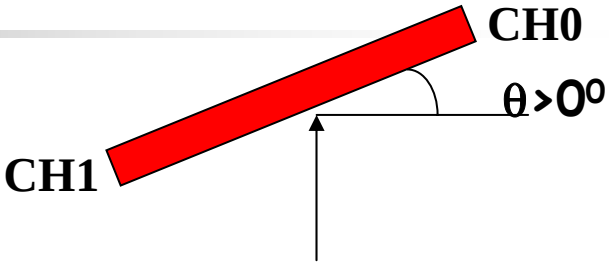
a) Landau (for the first tail) + Gauss (for the second peak)

b) Landau (for the first tail)+ Landau (for the second peak)





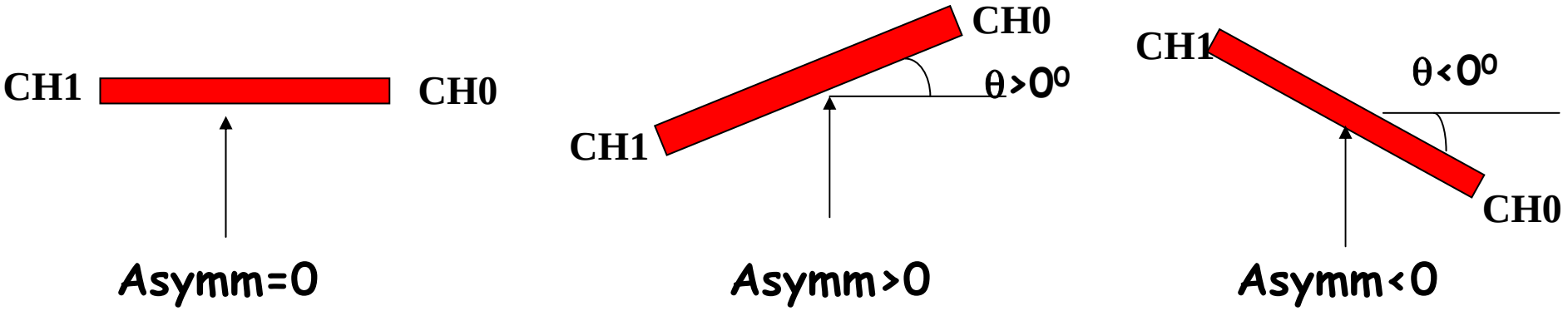


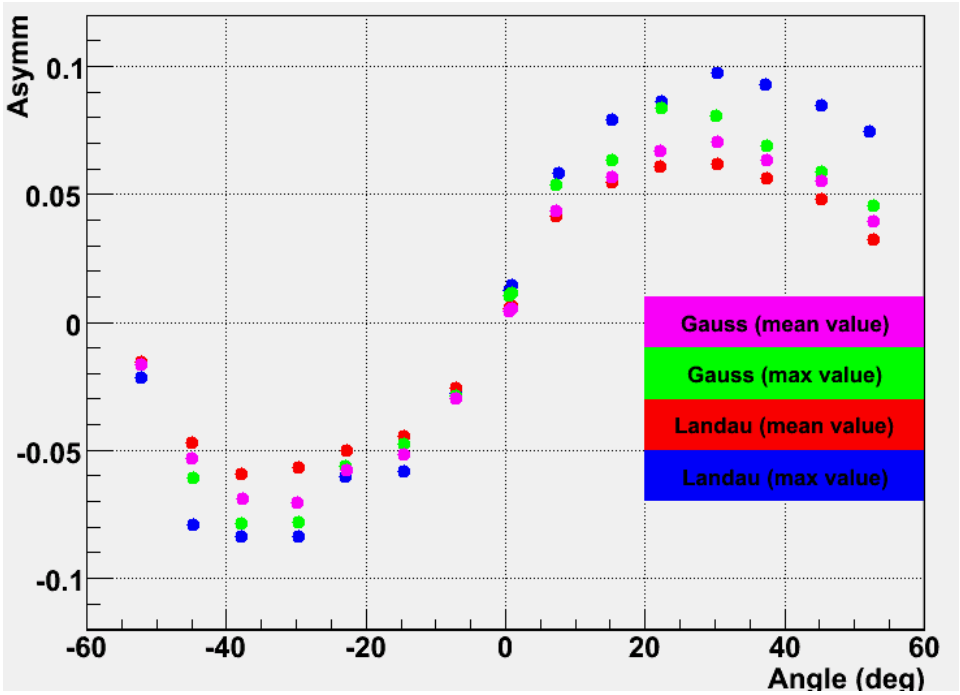


The ADC counts (prop. to the energy deposit) increase with the angle, because increases the track length.
For positive angles the CH0 counts are larger that CH1 ones because CH0 collects Cerenkov component (vice versa for negative ones).

Asymmetry

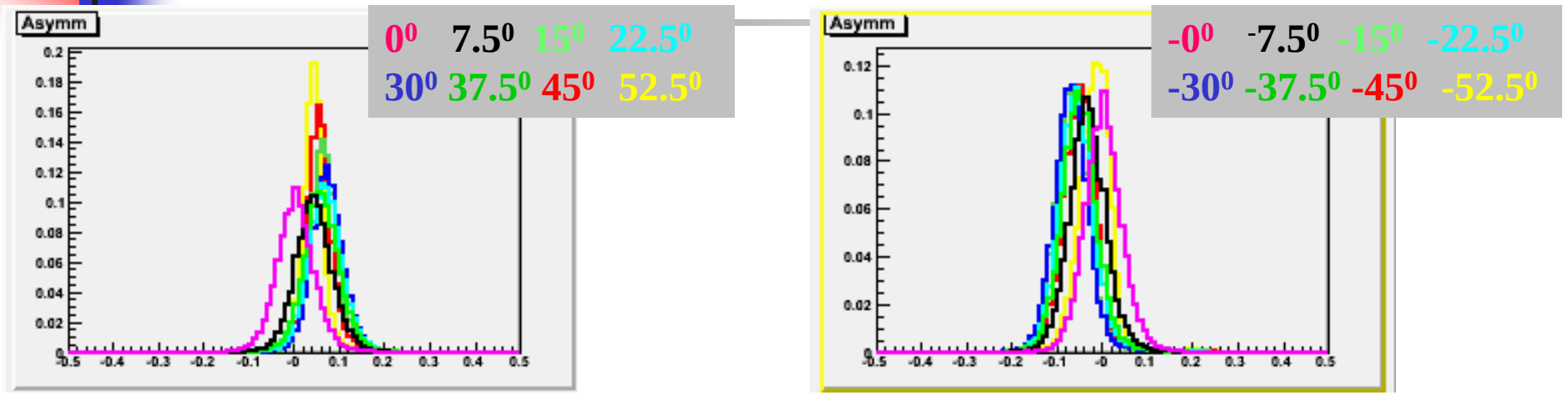
$$\text{Asymmetry} = \frac{ADC_{peak(mean)}(CH0) - ADC_{peak(mean)}(CH1)}{ADC_{peak(mean)}(CH0) + ADC_{peak(mean)}(CH1)}$$



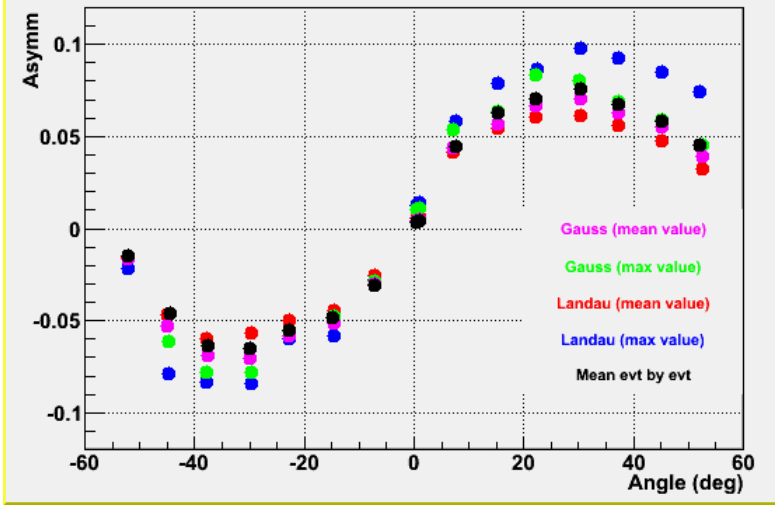


We have computed asymmetry also in a second way event by event at a fixed angle

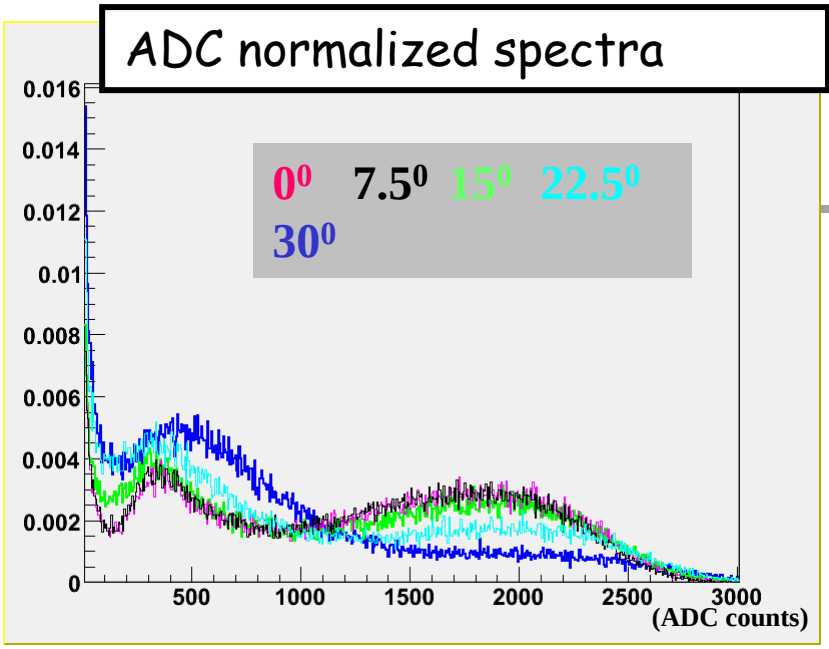
$$\text{Asymmetry} = \frac{ADC_{count}(CH0) - ADC_{count}(CH1)}{ADC_{count}(CH0) + ADC_{count}(CH1)}$$

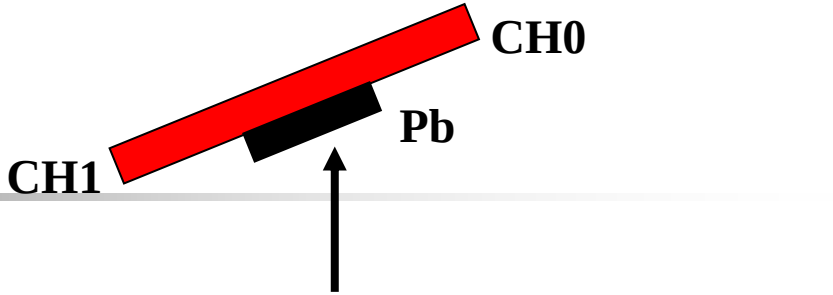


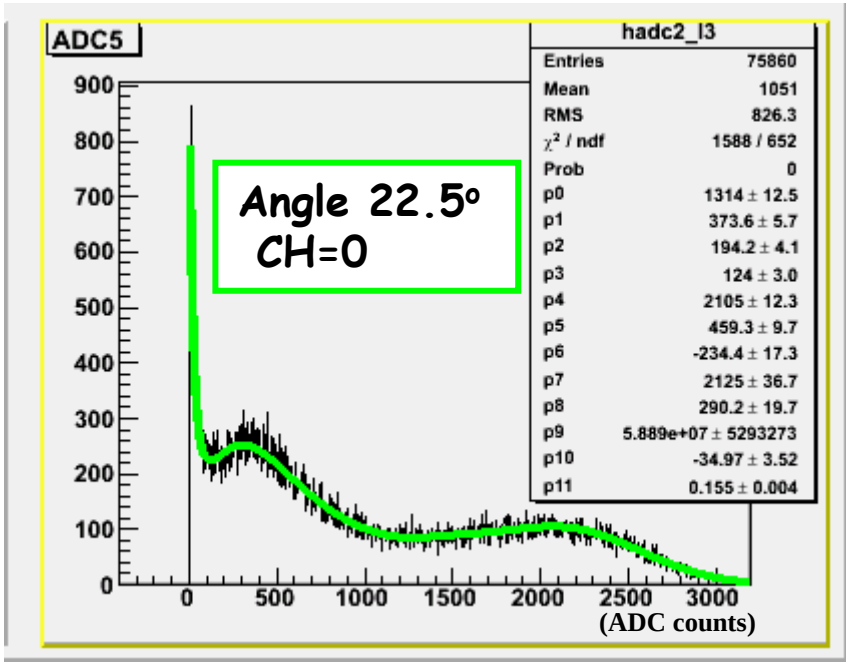
Taken mean value of the asymmetry distribution for each angle



10 GeV electrons shower in a late stage



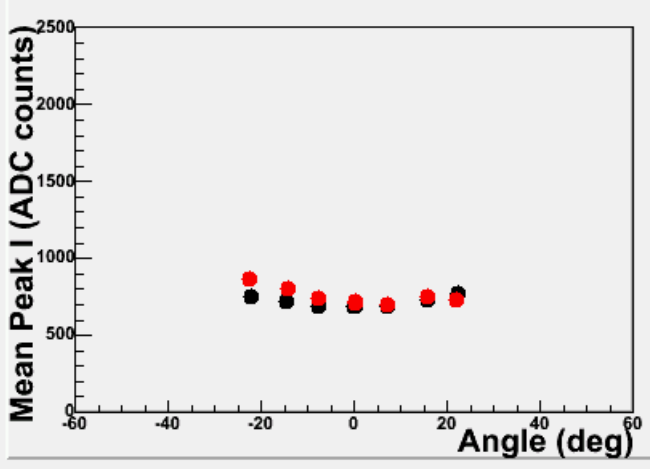




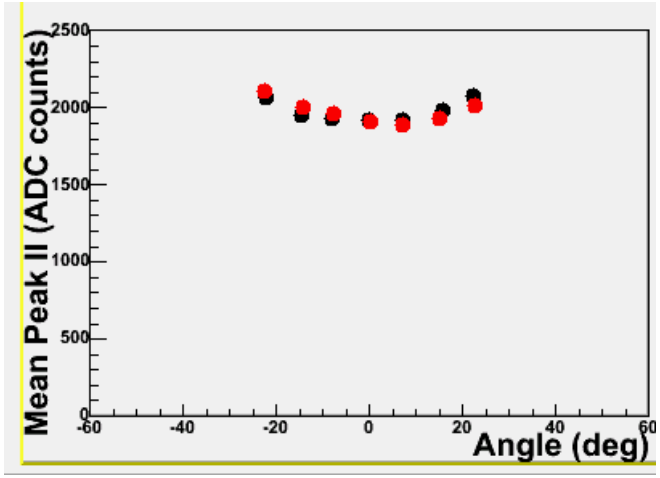
First tail related to e^- crossing near to the crystal edges
Second peak related to e^- crossing only the crystal
Thrid peak related to e^-crossing the Pb

Fit with a :
[Landau (first tail)]+ [Landau(second peak)]+[Landau+Gauss (thrid peak)]$_{12}$

Mean value of the e- crossing only the crystal (second peak) versus the angle

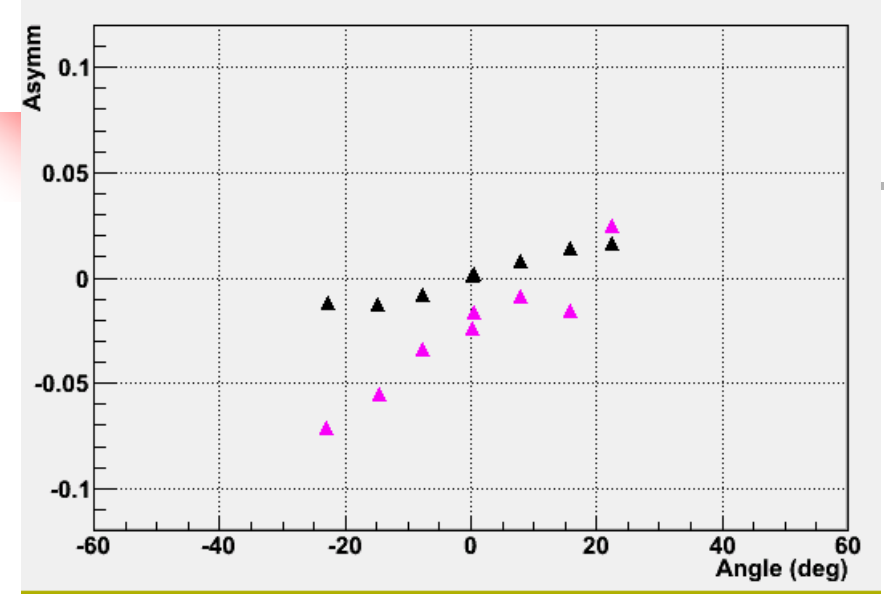


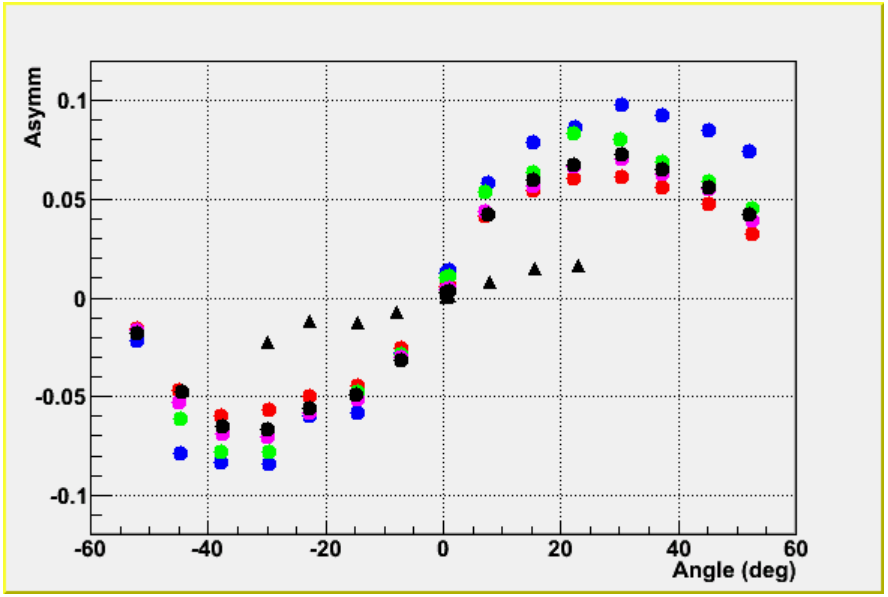
Mean value of the e- crossing the Pb (third peak) versus the angle



NOTE: the ADC channels for this set of runs are not equalized at 0^0, applied a multiplicative factor to ADC CH0 counts to equalize signals.

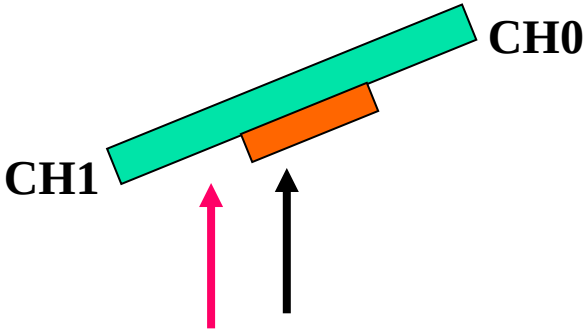
Asymmetry



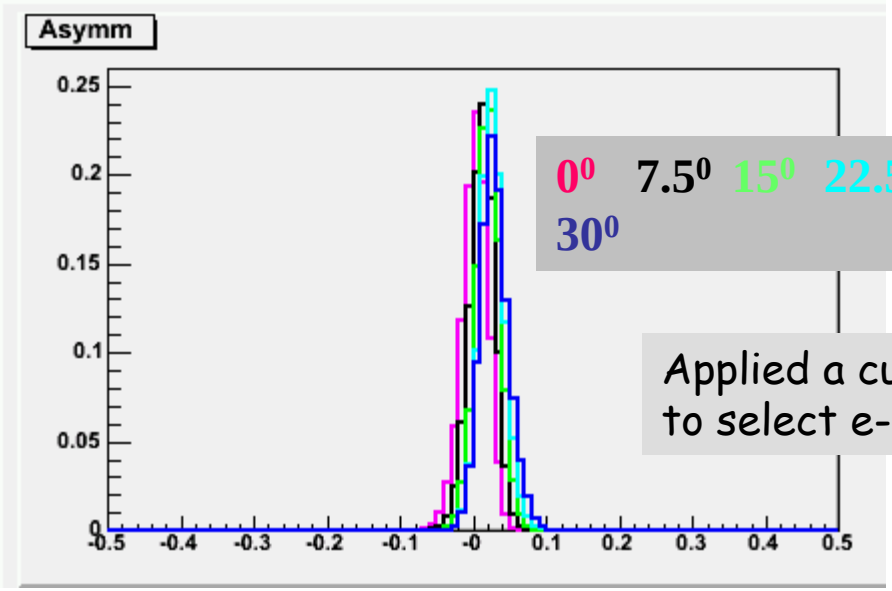


Asymmetry for e- crossing the Pb

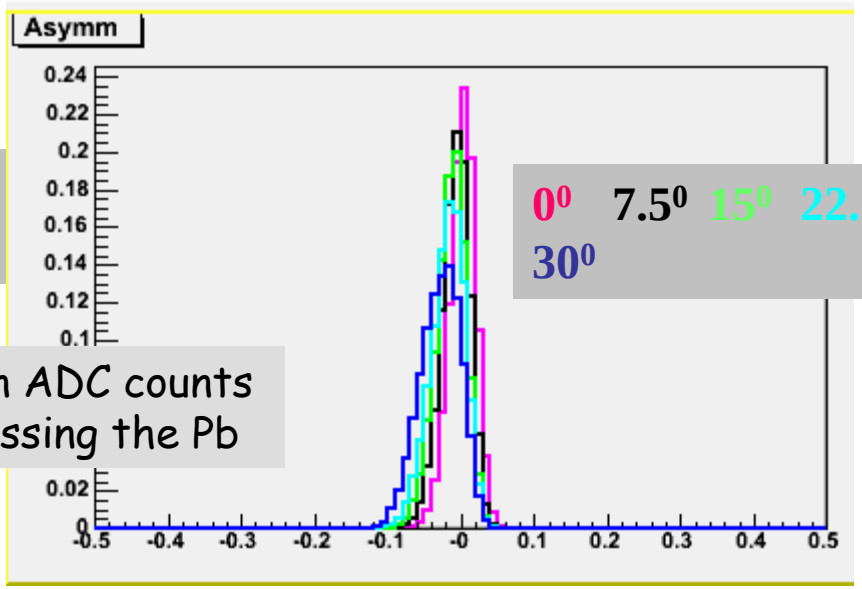
Asymmetry for e- crossing only the crystal (in this case $A \neq 0$ at 0^0, because e^- don't cross centrally the system)



Asymmetry computed event by event

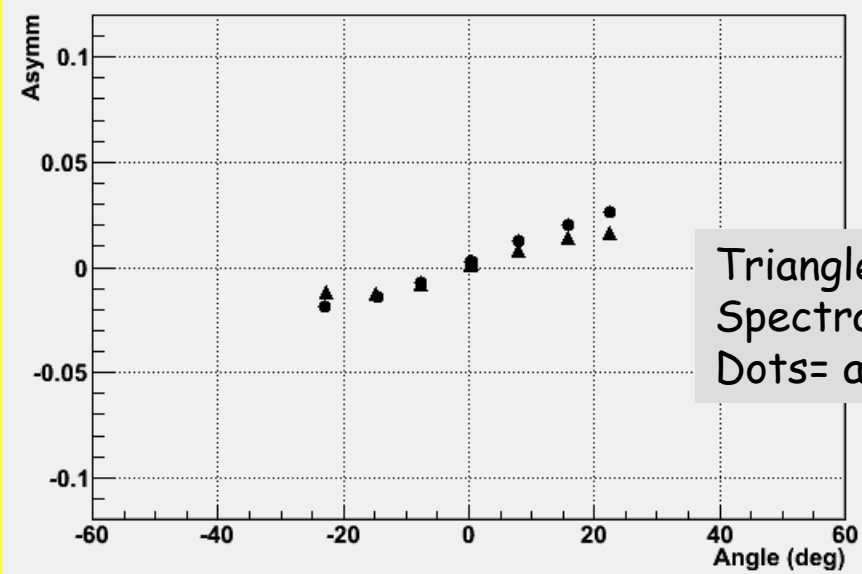


0^0 7.5^0 15^0 22.5^0 30^0



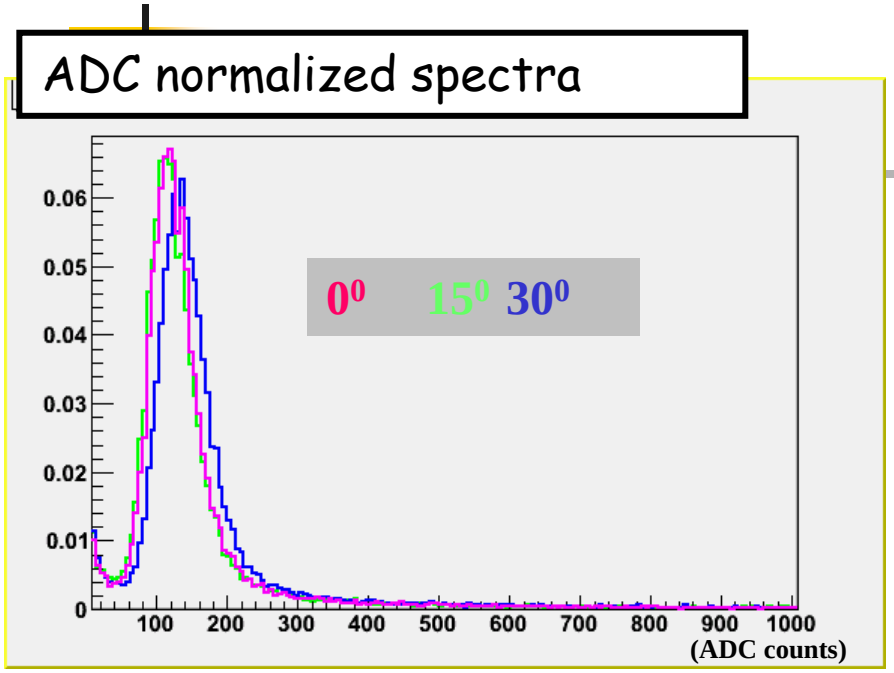
0^0 7.5^0 15^0 22.5^0 30^0

Applied a cut on ADC counts to select e- crossing the Pb

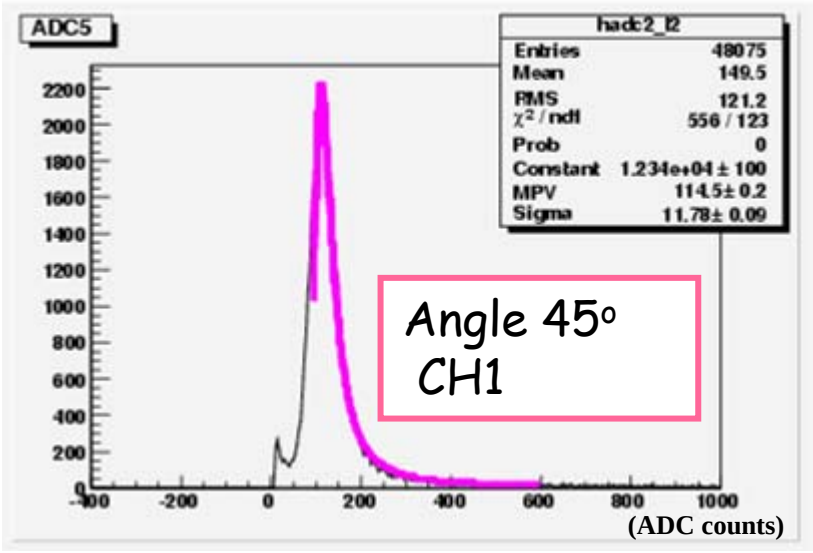


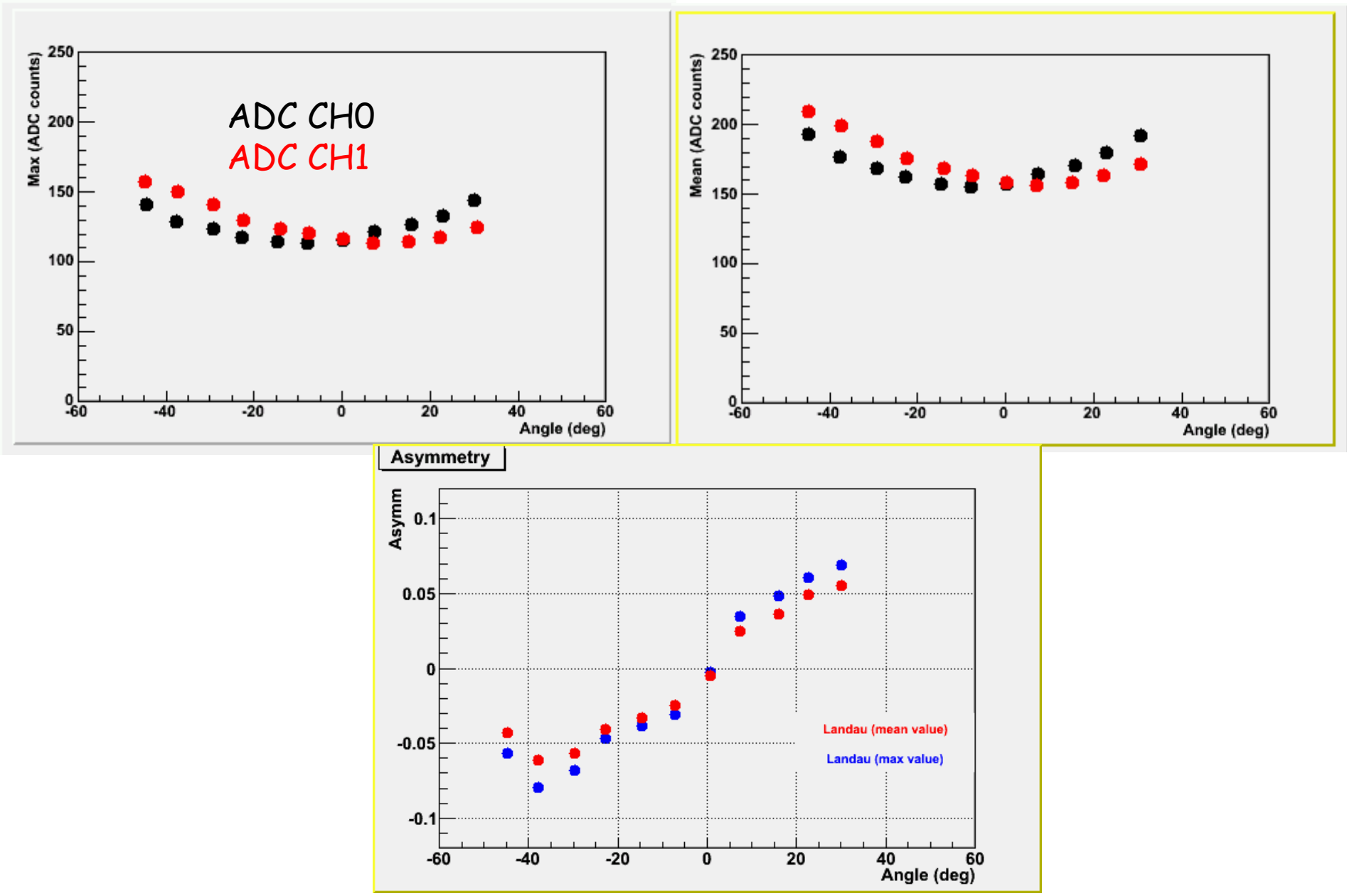
Triangles= asymmetry computed from ADC Spectra fit
Dots= asymmetry computed event by event

150 GeV Muons



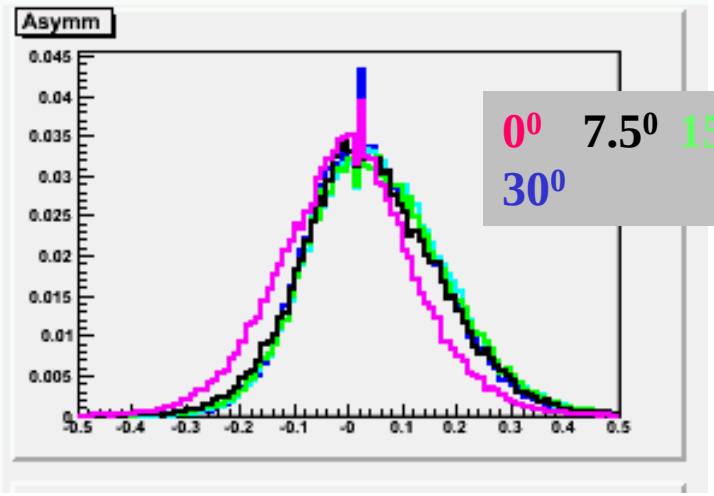
Fit with a Landau



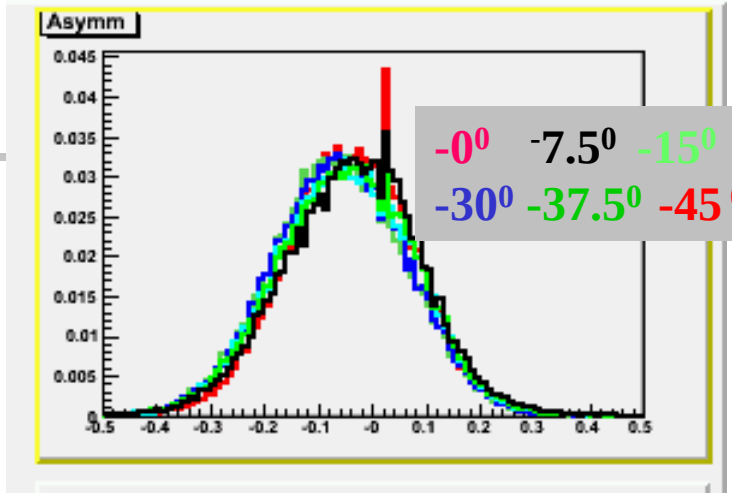


NOTE: the ADC channels for this set of runs are not equalized at 0^0 , applied a multiplicative factor to ADC CH0 counts to equalize signals.

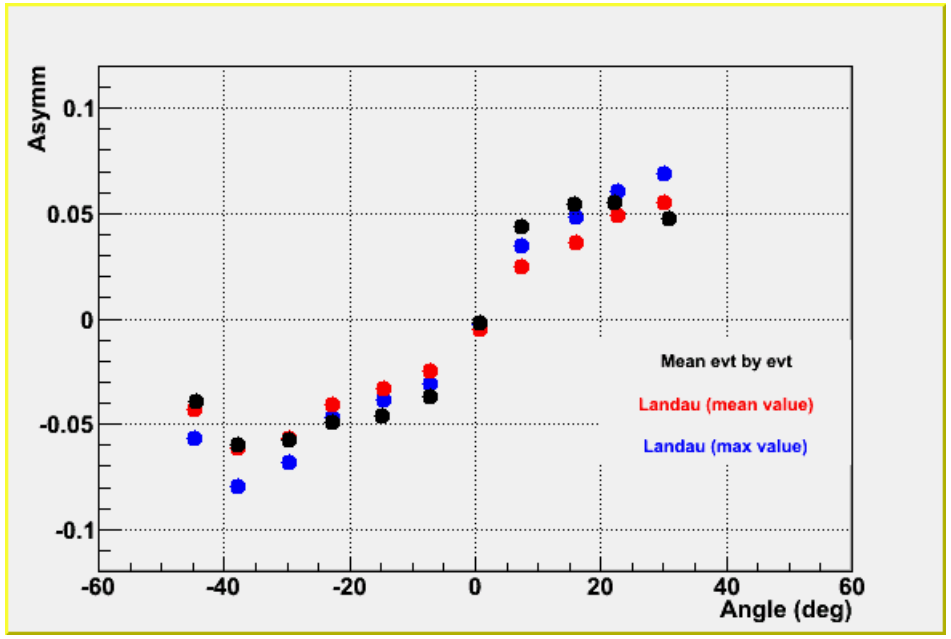
Asymmetry computed also event by event



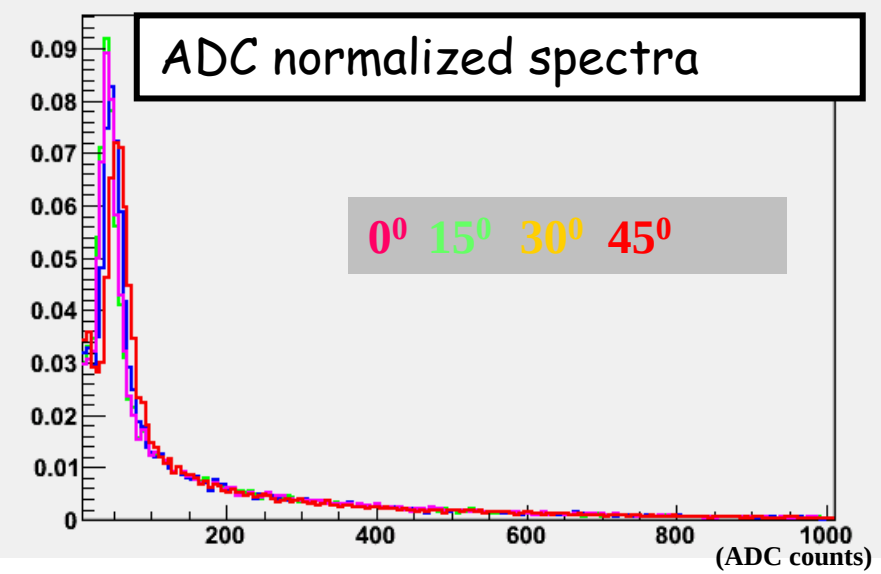
0^0 7.5^0 15^0 22.5^0
30^0



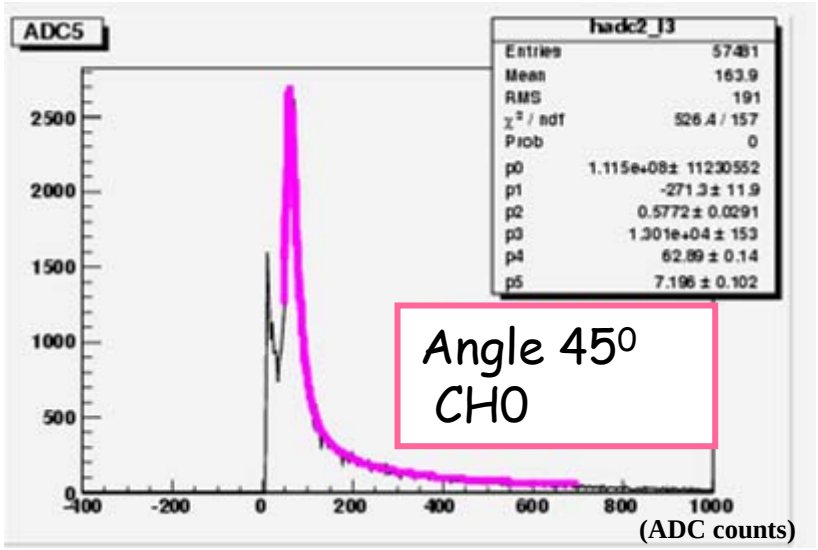
-0^0 -7.5^0 -15^0 -22.5^0
-30^0 -37.5^0 -45^0 -52.5^0



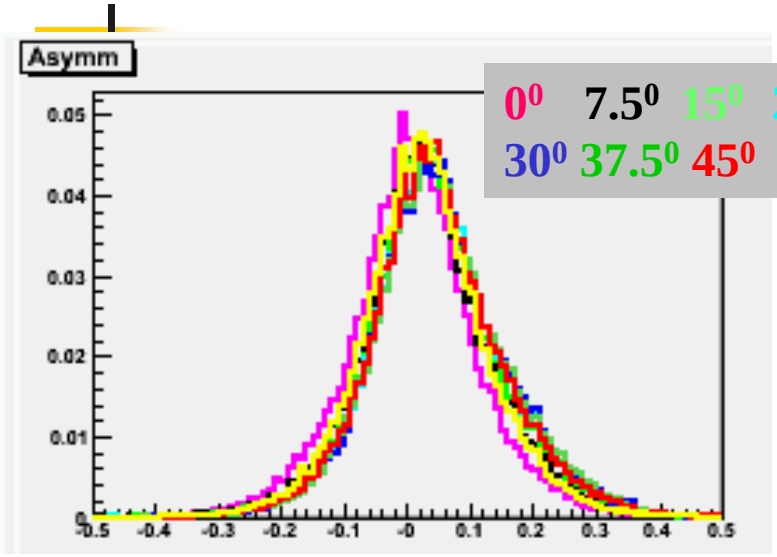
Parasitic Muons



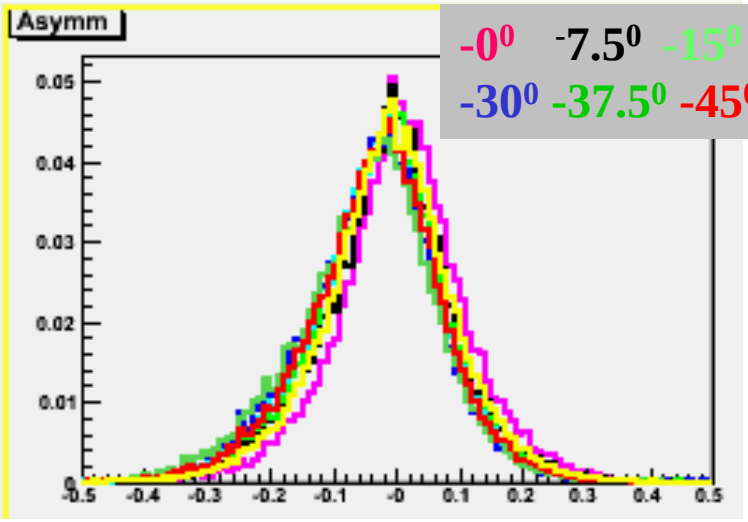
Fit with a double Landau



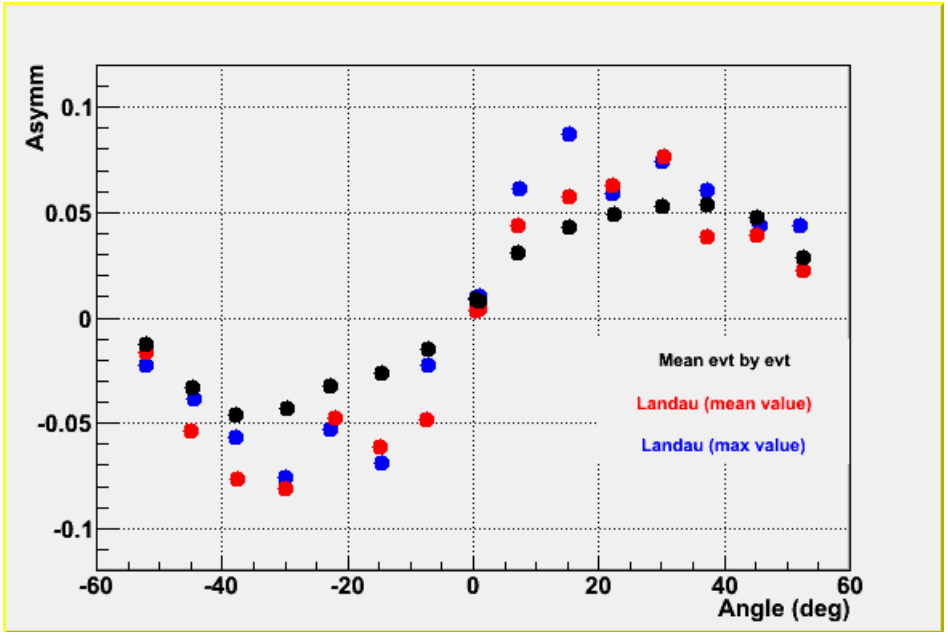
Asymmetry computed event by event



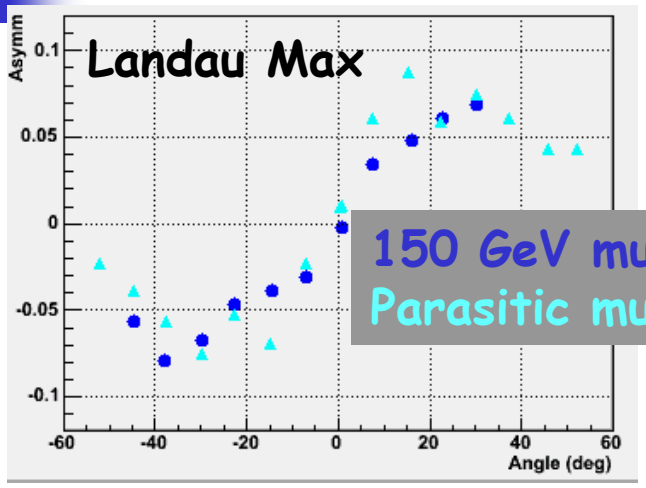
0^0 7.5^0 15^0 22.5^0
30^0 37.5^0 45^0 52.5^0

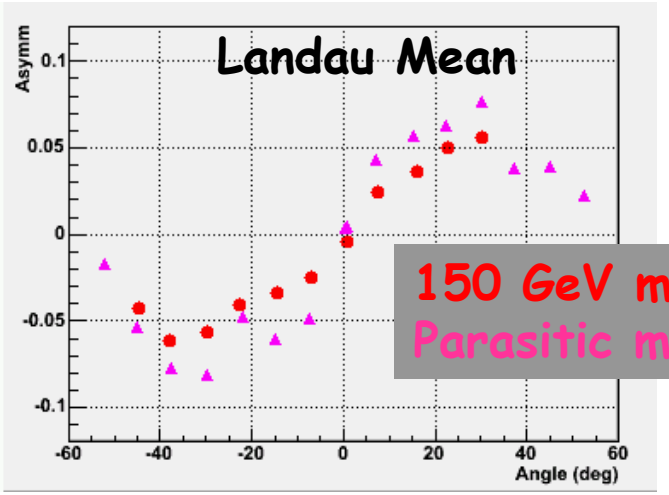


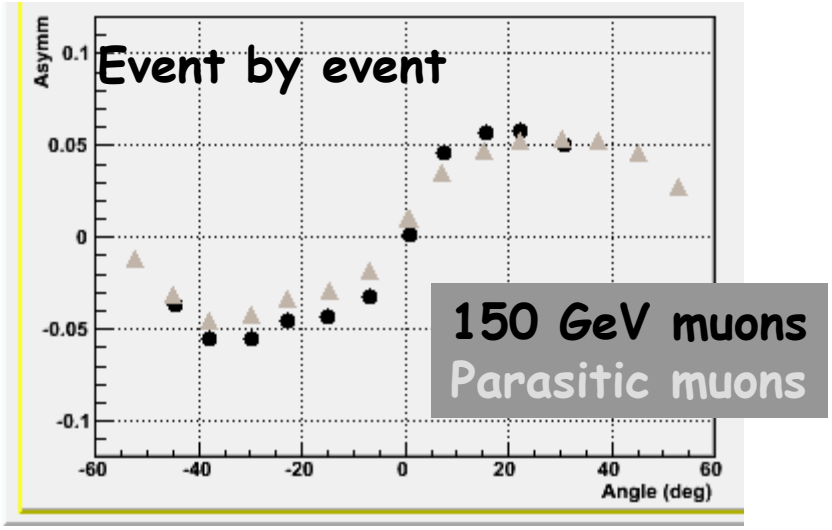
-0^0 -7.5^0 -15^0 -22.5^0
-30^0 -37.5^0 -45^0 -52.5^0



Comparison of asymetry between 150 GeV muons and parasitic muons

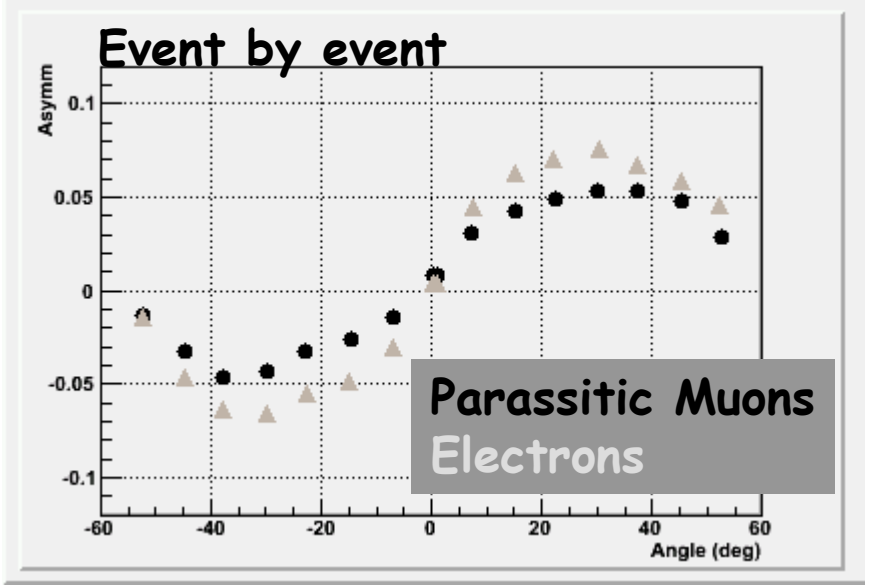


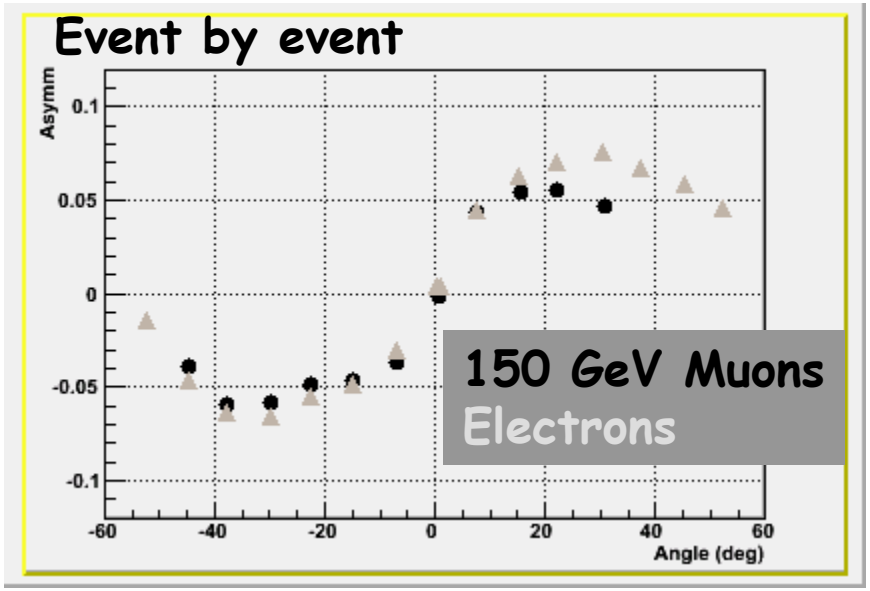




The asymmetry results for the 2 sets of muon runs are compatible

Comparison of asymetry between muon and electron runs





CONCLUSIONS

ADC signal shapes have been investigated for single crystal data both for electrons and muons measuraments:
the long tail from pedestal peak is related to showers only partially contained in the crystal (performed a check with the Monte Carlo simulation)

Asymmetry computed in two ways both from fit on ADC spectra and event by event: the first way more complex (fit with many parameters) than the second one.

For electrons shower in early stage the maximum asymmetry is ~6-9 % at ~30^0 . For muons the maximum asymmetry is ~5-8% at ~30^0-37^0 .

Asymmetry values are quite dependent from the method we use to define it and if the method by ADC spectra fit is used it depends on the fit range.

BACKUP SLIDES

RMS of event by event Asymmetry

Triangles = parasitis muons
Squares = 150 GeV muons
Dots = 10 GeV electron showers in early stage